CHILD SAFETY: WHO'S MOVE IS IT?

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ABSTRACT

Today's approval of Child Restraint Systems (CRS) according to ECE Regulation 44-03 does not take into account the latest state-of-the-art knowledge concerning child vehicle occupant safety. For instance, while the present fleet of passenger cars has an average deceleration pulse of 35g in a frontal impact, the peak deceleration achieved in the dynamic sled test for a CRS approval is considerably less severe at approximately 20g. New product innovations like ISOFix have taken too much time to get an industry-wide agreement and new assessment methods and tools such as the 'side impact procedure with Q-dummies' are after 8 years of research still not implemented.

The protection offered to child occupants in a passenger car accident could greatly benefit from a better co-operation between child restraint and car manufacturers and quicker implementation of new knowledge. Recognising this potential, the European consumer and government organisations wish for car manufacturers to be more responsible for the safely transport of children. These organisations are developing alternative test procedures that may overrule ECE R.44 in practise.

This overview paper presents the European trends on child safety today and aims to give more background to the forces that are into play. In particular, it will focus on the following aspects with regard to the child vehicle occupant safety:

- Influence of consumer (EuroNCAP) and government (EEVC) organisations;
- New research projects (CHILD), assessment methods and proposed rating techniques (NCAPS);
- CRS safety regulations and standards (harmonisation).

Reviewing the facts about child safety today, it is no longer justifiable to approve an interchangeable CRS, based on a single pulse sled test, as an universal safety product for all type of passenger cars, because the loading of child restraint systems is completely different in a passenger car test (Euro NCAP) than in a standard sled test (ECE Regulation 44).

INTRODUCTION

The last decades the protection of child car occupants in crashes has improved slowly. New test methods, including crash child dummies and injury criteria, have been proposed for frontal and side collisions only, however till today these proposals have never reached a legal status. Especially the ISO Working Group I and the EC project CREST contributed substantially to a better protection of children in cars. Today the following working groups are continuously improving the knowledge, methods and tools in these areas:

- GRSP/ECE R.44.03 [1]
- EEVC WG 18 [2]
- ISO/TC 22/SC 12/WG 1 Child Restraints (ISOFix/LATCH, Side Impact Studies) [2]
- CREST & CHILD (Accident reconstruction's, development of child dummies/Q-series) [3]
- Consumer testing (NPACS, EuroNCAP) [4]

However, it seems that the protection of children in cars is a decade or more behind compared to adults. Test methods for the evaluation of Child Restraint Systems (CRS) and child dummies were developed in the mid seventies. There is a lack of knowledge with respect to child injury biomechanics. The

existing CRS Regulation 44 is based on sled tests where the horizontal head displacement is a criterion, rather than for instance HIC and neck loads.

European accident investigations and experiences [1] show that in Europe 2 children are killed each day in a passenger car accident. In 1998, the total number of child car passengers killed in 19 European countries was 722. France was represented nearly 30% of the total, followed by Germany (18%) and Spain (13%). Also in some countries more than 50% of children are not correctly restrained. Unfortunately, these figures did not change over the last five years (1998-2003).

The work involved in the development of this paper is essentially archival research and information retrieval. As such it can be used by governments and industry for strategy decisions in the near future.

Regulation and Directives

In Europe, standards for restraining systems for children are controlled principally by **ECE Regulation 44** [1]. This regulation has been subject to important amendments and Regulation 44.03 brings improvements and innovations in a number of areas and is therefore the latest standard.

ECE Regulation 44.03 applies to child restraint systems which are suitable for installation in power-driven vehicles having three or more wheels, and which are not intended for use with folding (tip-up) or with side-facing seats.

This ECE Regulation 44.03 describes the requirements for child restraint devices and how to perform the various tests to verify correct function and performance. A child restraint device must be approved according to ECE Regulation 44.03 in order to be allowed to be used in automobiles in Europe.

Directive 2000/3/EEC [1] mandates Regulation 44.03 standards, but only for 'integrated' child restraints, i.e. where the child restraint is built into and converts from the car's seat. This Proposed Directive would require the use of child restraints approved to at least the standard of ECE Regulation 44.03 (or its equivalent).

Rearward facing child restraints are by far the safest form of restraint for younger children and they are most appropriately affixed to the front passenger seat where the driver can safely keep the child in vision. However, the child is vulnerable to serious injury if the front seat, passenger air bag inflates. Directive 2000/3/EEC requires that new cars be fitted with a label warning drivers of this risk. Similarly, rearward facing child restraints carry a warning but in both cases these may be ignored or not noticed by those that fix the child restraint to the front passenger seat. This proposal would prohibit the use of a rearward facing child restraint on a front passenger seat unless the relevant air bag has been de-activated (either disconnected or switched off).

Directive 91/671/EEC [1] requires the compulsory use of restraint systems by adults and children in all seating positions of cars and light vans where restraints are fitted. Children under 12 years of age and less than 150 cm tall must be restrained by an approved system that is suitable for the child's height and weight.

In national legislation, however, EEC Member States may allow children of 3 years and older to be restrained by a system that is approved for adult use. Also, Member States may exempt children younger than 3 years of age from wearing special restraint systems in rear seats if such systems are not available in the car.

Safety Rating Programs

Child protection has been part of the **EuroNCAP** [4] assessment from the start. Two child dummies are placed in child restraints in the rear seat. The dummies represents a 1.5 and a 3 year old child. For these age groups the child restraint plays an important role. From its inception EuroNCAP's underlying principle with regard to child safety has been to place the responsibility for child safety with the vehicle manufacturer. A modern car has properties that makes child safety an important and challenging part of the vehicle safety.

The objective of the **NPACS** [4] project is to provide the consumer with information about the relative dynamic performances and usability of universally approved child restraints in front, rear and side impacts, with the goal of improving the safety afforded to children in vehicles. The intention is to develop a test programme that generates independent consumer information. The assessment programme will begin by the purchase of child restraint systems across the current available range, which will be subjected to a number of tests. The restraints will be assessed against given criteria in order to award them a star rating and the results will be published in the consumer domain. Then child restraint manufacturers can be invited to have their seats assessed and promoted periodically, and the consumer information can be updated accordingly.

Safety Research Programs

The objectives of the European **'CHild Injury Led Design'** (CHILD) research project [3] are the determination of child injury tolerance and a proposal for a validated procedure for Child Restraint Evaluation. It is based on the study of around 300 road accidents involving restrained children, improvement of dummies, performing 35 full scale tests and 50 additional parametric tests , improvement of numerical child dummy models and development of new ones, modelling of human body segment and virtual accident development using hybrid models. These results will consolidate the ones of the '**C**hild **R**estraint **S**ystem S**t**andard' (CREST) program (1996-2000) where some injury risk curves have been determined for frontal impacts and will permit the construction of such curves for side impacts. This will lead to validated procedures both for frontal and side impacts with improved dummies and injury criteria corresponding to the body segments on which children are injured according to their age and the type of restraint systems used.

Seven European countries are involved in the CHILD project. All partners have a substantial interest in child protection and a long experience in the field of passive safety. Moreover, the partners have complementary profiles: car and child restraint manufacturers, research organisations and universities.

An important reason for extending this project at the European level is that child safety legislation is established at the EU level (Communication on Road Safety). In addition, CHILD seeks to complement the activities of EuroNCAP and NPACS with regard to child occupant protection assessment.

STANDARD OR REALITY?

Children are smaller, lighter and (in some body areas) more vulnerable than adults. Young children need 'extra devices' to sit in or to be restraint to the car using adult belts. This introduces extra slack between child and car and therefore reduces the protection. In the last 25 years several recommendations of second importance were adopted in ECE Regulation 44.03 to improve the passive safety of children in passenger cars. However, crash pulse, child dummies and for example also the injury criteria which are of main importance to improve the protection offered to children travelling in passenger cars are not reviewed and still exist today. With respect to the high protection standards for the protection offered to adults, this is really confusing. For a number of reasons, new child restraint product innovations like ISOFix have taken too much time to get an industry-wide agreement.

Regulation and Directives

Today's approval of Child Restraint Systems (CRS) according to ECE Regulation 44-03 does not take into account the latest state-of-the-art knowledge concerning child vehicle occupant safety. For instance, while the present fleet of passenger cars has an average deceleration pulse of 36g (Table 1) in a frontal impact, the peak deceleration achieved in the dynamic sled test for a CRS approval is between 20 and 28g, but the considerably less severe pulse at approximately 20g has become the standard in Regulation 44.03.

Table 1 [EuroNCAP results]

Average	36 g
Median	34 g
Maximum	63 g
Minimum	23 g

However, not only the crash pulse of the impact sled should be changed to improve the level of protection offered to children travelling in cars, but also the geometry of seatbelt, the stiffness of seat cushions, the buckle strength and release system, the labelling to encourage appropriate restraint use, the procedures for integrated child restraints, the seats for disabled children and the provision of a short crotch strap have to be redesigned to the present state. Summing up the test sled does not really represent the actual situation in current production cars. The only compatibility check in ECE 44 is the so called consolidated resolution 3 that checks the belt length and buckle position, on a voluntary basis. Theoretically CRS can be developed without any try out in real cars.

The P-series of child dummies was developed in the 1970's. The first versions became available around 1974, and a complete series, consisting of a new-born, a 9 month old (P3/4), a three year old (P3), 6 year old (P6) and a 10 year old (P10) was available around 1976-1977. The dummies became official in 1981, when the European ECE/R.44 [1] regulation came into force. The last 25 years the protection offered to children travelling in cars has increased dramatically due to a better understanding of the dynamical behaviour of children and the resulting improvements to CRS. To further improve child safety it is absolutely confusing that the European P-series are not yet replaced with the more biofidelic European Q-series, which are not only developed for use in frontal impacts, but can also evaluate the protection offered to children in lateral impacts.

And a main confusion today is also the lack of biomechanical knowledge regarding the injured children in passenger car accidents. The existing injury criteria, for example the 30g vertical chest acceleration, are from the time when ECE/R.44 came into force (February 1, 1981).

Additionally, it is confusing that after 8 years of research the approval of CRS do not consider a dynamic sled test in order to be able to determine the protection of a system in a side impact configuration. Side impacts are the second most frequent type of accident, causing relatively many injuries. It has appeared to be a big lack in term of children protection, the ISO/WG 1 has then decided to have an ad-hoc group working specifically on the definition of a procedure for testing CRS in side impacts, however there are still too much uncertainties concerning the best parameters to simulate in a single sled impact test.

Safety Rating Programs

In 1997 the EuroNCAP program started, where two child seats with child dummies are placed in the rear of each car tested. Also the user instructions of the CRS are taken into account. The CRS in test were those recommended by the car manufacturer. Some responsible manufacturers have developed a range of dedicated child restraints for their car models. But most of them use existing seats on the market, re-labelled or not. The results were interesting. Surprisingly the same seat delivers different performances in different cars. And the results were not as good as in ECE 44 tests.

The main outcomes of these tests performed within EuroNCAP till today are that:

- main CRS are designed for frontal impact only;
- main part of misuse is coming from the incompatibility between the car rear bench and the CRS;
- simple pictograms and self explaning designs are more efficient for the reduction of misuse than too complex notices.

One of the effects of EuroNCAP is that car manufacturers make their passengers compartments stronger to avoid front occupants being directly injured by the intruding dashboard. This tends to lead to increasing forces on those car occupants who are seated away from the part of the passenger compartment that would have previously folded up. For adults there are sophisticated mechanisms that control these forces well: airbags, pre-tensioners and load limiters in the belt system. CRS in the back of the car in general don't benefit from these high tech solutions and bigger forces will have to absorbed. Despite the testing many car manufacturers show a low degree of focus on child safety.

DILEMMA

In Europe, the following organisations are taking there own responsibility for protecting children in cars:

- National Ministry of Transport with Directive 91/671/EC
- National Approval Authorities (Testhouses) and Industry (CLEPA) with Regulation 44.03
- Consumer Testing performed by EuroNCAP, NPACS, consumer magazines (AIT&FIA and ICRT) and car magazines (AutoBild, What Car, and Auto Motor und Sport)
- Research Studies: EC CHILD, ISO/WG 1 and European Vehicle Passive Safety Network (PSN)

These four different groups, including the different ISO Working Groups, work rather autonomously. They take there own responsibilities, which results in different levels (and lacks) of knowledge.

The "Research Groups" focus on the technicalities of child safety, the "Consumer Groups" also look at usability and practical performances. "Governments together with the National Testhouses" mainly take care of the formal sides, thus lacking behind the actual state of the art. The industry (CLEPA), seeks the lowest comment denominator in standardisation, determined by their weakest member.

The lack of communication between Government (Directives/Regulations) and Research Groups/Industry contributes to lack of improvement of vehicle child safety in the near future. The NPACS initiative could solve this problem, as all disciplines mentioned above (governments, research institutes and consumer organisations) are part of this consortium.

Further more, improvements in child safety can be achieved by a stronger contact between child restraint manufacturers and car manufacturers. This is necessary in order to have a better compatibility of both products when used together. The development of ISOfix should re-enforce that co-operation in order to reach the normal objective common to consumers, car manufacturers and CRS manufacturers, have a simple and interchangeable system to protect young occupants.

Safety Rating Programs

Unfortunately, EuroNCAP has until now not given much focus on the child rating. The CRS rating is not integrated into the over all score of EuroNCAP tested vehicles and no actual rating has been presented for the child safety and the test results have in principle only been communicated in the brochure. As an effect of this the practical influence on child safety is limited at this stage. However, a separate rating for the child restraint performances in EuroNCAP tests is foreseen in the near future.

Not being encouraged by a rating several car manufacturers are not likely to pay a lot of attention to their CRS systems. They develop family cars, but seem to take less responsibilities for the safe transport of children. From that point of view, today's cars are only developed for transporting adults and unfortunately not for children.

Concluding we see that there is a mismatch between cars and CRS. The current situation that it is possible to develop CRS in isolation (ECE/R.44 only) is undesirable.

DISCUSSION AND CONCLUSIONS

European research and experience has shown that the use of child restraints is a highly effective way of reducing serious and fatal injuries to car child occupants. The effect of child restraints in reducing serious injuries is around 90% for rearward facing systems and around 60% for forward facing systems.

ECE Regulation 44.03 has brought improvements and innovations in a number of areas of approving child restraints, however the present test procedures are not according to the state-of-the-art technologies regarding vehicle occupant safety.

The revised Directive 91/671/EEC requires the use of child restraints approved to at least the standard of ECE Regulation 44.03 (or its equivalent). The Directive 91/671/EEC

prohibits also the use of rearward facing child restraints in a place fitted with fronal airbags unless the relevant airbag has been de-activated. It is hoped that these changes will one day become mandatory.

The majority of child restraint devices are manufactured by companies other than car manufacturers, so child restraints are normally added by the car owner, rather than integrated into the original design of the car. Incorrect installation may result and this can reduce the effectiveness of the child restraint system.

The protection offered to child occupants in a passenger car accident could greatly benefit from a better co-operation between child restraint and car manufacturers and quicker implementation of new knowledge.

EuroNCAP wants car manufacturers to be more responsible for child protection than they are now and will deliver a seprate rating for the protection of children in the cars tested before long.

Unfortunately, solutions to protect adult car occupants (like airbags) are not necessarily improving the protection of child occupants. Moreover, it seems that the protection of children in cars is a decade or more behind compared to adults. Test methods for the evaluation of child restraint systems (CRS) and child dummies were developed in the mid seventies. There is a lack of knowledge with respect to child injury biomechanics. However, the level of knowledge about good child restraint protection is now so advanced that poor design becomes increasingly difficult to accept.

Therefore: "The optimal safety performance for children can be achieved when all child restraints have to fulfil state of the art requirements, and that vehicle manufacturers take full responsibility for the development of such designs. The consequences could be that universal CRS have to perform well in a range of dynamic tests reflecting the actual car fleet as opposed to the current single pulse sled test (NPACS). Another market development could be that more vehicle-specific systems (that cannot be moved between different car models) will appear on the market (EURONCAP). "

REFERENCES

1. Regulation and Directives:

- ECE Regulation 44.03: Uniform Provisions concerning the approval of restraint devices for child occupants of power-driven vehicles ("Child Restraint Systems"); First published in February 1, 1981; Latest revision 1, June 1 1998 (Amendment 03)
- Directive 2000/3/EEC is relating to safety belts and restraint systems of motor vehicles.
- Directive 91/671/EEC is relating to compulsory use of safety belts in vhicles of less than 3.5 tonnes

2. Working Groups:

- EEVC WG 18: European Enhanced Vehicle-Safety Committee, Research Works on Child
- ISO/TC 22/SC 12/WG 1: Child Restraint Systems (in Road Vehicles)

3. Research Studies:

- CHILD: EC Project "CHild Injury Led Design"

4. Consumer Testing:

- NPACS: New Programme for the Assessment of universal Child restraint Systems.
- EuroNCAP: European New Car Assessment Programme.

5. Abbrevations:

- ADAC: Allgemeine Deutsche Automobil-Club
- AIT&FIA: FIA Foundation for the Automobile and Society
- CLEPA: European Association of Automotive Suppliers
- EEC: European Economic Commission
- ECE: Economic Commission for Europe
- ECE/WP.29/GRSP: Working Party on Passive Safety
- ICRT: International Consumer Research & Testing
- PSN: European Vehicle Passive Safety Network